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ABSTRACT

This study explores the use of Valsiner's zone theory as a way to interpret the zones of proximal development of three secondary school teachers in mathematics and science. Specifically, researchers used classroom discourse to identify what the participating teachers promoted (zone of promoted action) or allowed (zone of free movement) in the classroom as a way to better characterize their potential for development. They found that teachers who promoted actions or events that they ultimately did not allow students to experience seemed to be at a point in their development analogous to Vygotsky's pseudo-conceptual stage, prior to full concept formation. Moreover, they found that, at this stage, the existence of a communal zone of proximal development in the classroom seemed to affect the teacher's transition toward more desirable forms of practice. Finally, they found that identifying the restrictiveness (or openness) of the zones teachers established for their students offers insight into how to organize the learning environment in a mentoring relationship with teachers. (Contains 18 references.) (Author/SM)

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Using Valsiner's Zone Theory to Interpret Change in Classroom Practice: Beyond the Zone of Proximal Development

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Abstract

This study explores the use of Valsiner's zone theory as a way to interpret the zones of proximal development of three secondary teachers in mathematics and science. Specifically, we used classroom discourse to identify what the participating teachers promoted (zone of promoted action) or allowed (zone of free movement) in the classroom as a way to better characterize their potential for development. We found that teachers who promoted actions or events that they ultimately did not allow students to experience seemed to be at a point in their development analogous to Vygotsky's pseudo-conceptual stage, prior to full concept formation. Moreover, we found that, at this stage, the existence of a communal zone of proximal development in the classroom seemed to affect the teacher's transition toward more desirable forms of practice. Finally, we found that identifying the restrictiveness (or openness) of the zones teachers established for their students offers insight into how to organize the learning environment in a mentoring relationship with teachers.

Introduction

In a Vygotskian perspective on learning, the zone of proximal development (ZPD) is postulated as the space characterizing one's potential capacity for development through the assistance of a more knowing other (Vygotsky, 1962/1934; Litowitz, 1993). Moreover, it is predicated upon how that more knowing other organizes, or "scaffolds", the task at hand. In other words, as we infer from Diaz, Neal, and Amaya-Williams (1999), one's development within the ZPD is affected by the intellectual quality and developmental appropriateness of interactions with a more knowing other. As such, our understanding of the ZPD has implications for the instructional contexts we create to shape development. However, despite the ZPD being appropriately set forth as "a necessary condition for human development" (Oerter, 1992, p. 187), it is largely inaccessible as a diagnostic for instruction. What it promises in theory (that is, a sense of how tasks can be scaffolded so as to optimize learning) is obscured in practice. Thus, given the significance of the ZPD, our directive as teacher educators becomes understanding how to analyze the teacher's ZPD from a more accessible route so that we can effectively scaffold his or her development. We find support for this directive among scholars (e.g., Rogoff & Wertsch, 1984) who encourage a better understanding of the novice's position within a task as a way to create better scaffolding for that novice. At issue then is finding a means to understand the novice's ZPD, and for our purposes, the novice teacher's ZPD. To this end, this study explored the use of Valsiner's (1987) zone theory as a more direct way to interpret a teacher's ZPD. In particular, we used his theory to interpret the classroom learning environments established by three secondary teachers in mathematics and science. In what follows, we examine Valsiner's zone theory in the context of these teachers' practices and use this to make inferences about their development within the ZPD. First, we consider Valsiner's theory in its original meaning.

Interacting Zones as a Model of Development

Valsiner (1987) expanded Vygotsky's notion of the ZPD to include two additional zones of interaction: the zone of free movement (ZFM) and the zone of promoted action (ZPA). As structures through which an adult constrains or promotes the child's thinking and acting, the ZFM/ZPA complex interactively generates the environment in which that child develops. In particular, the ZFM is a binding agency by which the adult restricts the child's access to areas, objects, or ways of acting on such objects (Lightfoot, 1988). Valsiner describes it from a developmental perspective as an "inhibitory psychological mechanism" (p. 99) that the adult creates to constrain the freedom of the child's choices of thinking and acting. In essence, the ZFM addresses the question of what is allowed by the adult. Moreover, the ZFM is "simultaneously a structure of the child's actions within the environment at a given time, and the future thinking of the child" (Valsiner, 1987, p. 98). In other words, the way an adult organizes the ZFM portends the nature of the child's thinking about the concept being taught. In this sense, the ZFM ultimately canalizes the direction of development for the child, providing a framework for cognitive activity. Lightfoot (1988) illustrates the ZFM by a mother's action while feeding her child. In the process, the mother may use a high chair to restrict the child from moving around the room. She may further narrow the ZFM by holding the child's flailing arms. Ultimately, the idiosyncratic ways she structures mealtime activities will be internalized by the child and be reflected in his eating practices.

On the other hand, the ZPA defines a "set of activities, objects, or areas in the environment" (Valsiner, 1987, pp. 99-100) by which an adult attempts to persuade a child to act in a certain way. It describes what the adult is promoting, with no obligation for the child to accept what is being promoted. Consider again the previous illustration. A mother might place a spoon in front of her child and try to persuade the child, through verbal antics, to pick up the spoon. In this case, the action of eating with a spoon is being promoted. Note that the mother may (with good reason) decide to place the spoon in the

child's hand and enact the motion of putting food in the child's mouth. At this point, the ZPA has become the ZFM: What the mother previously promoted she now obligates the child to accept. In such cases, the ZFM and the ZPA can be seen as equivalent. That is, the child's only choice is what the adult requires (Westbrook, Carter, & Smith, 1997).

As this mother/child scenario suggests, the ZFM and ZPA are dynamic, interdependent constructs that are continually being reorganized in the learning process (Valsiner, 1987). The question remains as to how these zones interact with the ZPD. First, we note that one can only promote (ZPA) what is at least allowed (ZFM). Hence, we can visualize the ZPA as contained within the ZFM. Additionally, if what is promoted is not within the individual's ZPD, then optimal development cannot occur. Conversely, instructional efficacy is optimized when the relationship between the ZPA and ZPD is such that what is promoted (ZPA) lies within the individual's ability to achieve this (ZPD). Valsiner (1987) further argues that only a portion of one's potential can be realized in a particular situation at a given time; hence the ZPD cannot be fully contained within the ZFM. That is, since the ZFM is socioculturally determined, the child can only develop those aspects of the ZPD that are advertised by the adult (ZPA) and not prohibited (ZFM) by the culture in which he or she is acting. This anomaly exists because in every social interaction where development is promoted, a "canalization occurs that excludes other options of the ZPD" (Oerter, 1992, p. 193). In other words, when a particular experience is promoted (and hence allowed), some other event is necessarily excluded. To further clarify Valsiner's theory, we include here our rendering of Oerter's (1992) depiction of the relationship between these three zones:

[INSERT FIGURE 1 HERE]

Figure 1. Interaction of the ZFM, ZPA, and ZPD in development.

The classroom provides an illustration of how these zones interact, since it requires teachers to continually make decisions about what to promote (hence allow). For example, if a teacher chooses to promote only individual seatwork comprised of repetitive mathematical exercises, then he or she is necessarily excluding the possibility of an open, inquiry-based classroom from the ZFM/ZPA complex. As a result, the student's full potential of development within the ZPD cannot be realized because he is not exposed to collective mathematical inquiry. In this case, the learning environment (ZFM) necessary for establishing a ZPD in which students realize their potential for mathematical thinking based on activities of public conjecturing and argumentation fails to be established. The implication is that the ZPD would not be fully contained within the ZFM, thereby creating the canalization that Valsiner (1987) describes (see Figure 2).

[Insert Figure 2 about here.]

Figure 2. An interaction of the ZFM, ZPA, and ZPD in a classroom context.

Using the ZFM/ZPA Complex to Interpret the Teacher's ZPD

Given the interdependence of these three zones, if we consider that the ZPD is ontogenetic, or within the learner and the ZFM/ZPA complex is microgenetic, or between the learner and the environment and hence observable (see Lightfoot, 1988), then it seems reasonable to explore a teacher's ZPD through the ZFM/ZPA complex. To this end, our goal was twofold. First, we identified the ZFM/ZPA complexes organized by one secondary[1] science teacher and two secondary mathematics teachers for their respective students. Our particular goal was to use the classroom learning environments established by these teachers to describe what they allowed and what they promoted during their lessons. Secondly, we explored what this interpretation of the ZFM/ZPA complex revealed

[1] The term 'secondary' is used here to include grades 6-12.

about their teaching practices as a way to better understand their capacity for professional development within the ZPD.

In a previous study, Westbrook, Carter, and Smith (1997) initiated this interpretation of the zone concepts in the context of teacher education. By examining the ZFM/ZPA complex organized by a cooperating teacher as a point of entry into the student teacher's ZPD (see also Carter, Westbrook, & Wheatley, 1998), they found that professional development was most likely to occur in situations where the cooperating teacher structured a large ZFM and promoted actions that were within the student teacher's ZPD. Herein lies a subtle abstraction in our approach. That is, rather than examining the way a cooperating teacher organizes the student teacher's learning environments as a window into the student teacher's ZPD, we propose that the way the novice practitioner organizes the ZFM/ZPA complex in the classroom for his or her students informs the teacher educator about that teacher's development within the ZPD. In essence, we argue that identifying what the teacher promotes (ZPA) or allows (ZFM) within the classroom will enable teacher educators to more effectively scaffold the teacher's development. In this sense, we claim that the ZFM and ZPA provide a more accessible route into the teacher's ZPD.

Using Classroom Discourse to Articulate the Teacher's ZFM/ZPA Complex

We used classroom discourse or, specifically, utterances made by teacher and students in the classroom, to identify the ZFM/ZPA complexes organized by the teachers participating in this study. Discourse applied to practices of teaching has become a significant topic for educational inquiry from various theoretical perspectives, ranging from quantitative, behaviorally based approaches (Carlsen, 1993) to ethnographic, sociolinguistic analyses (Roth, 1996). In particular, explorations in patterns of discourse used by both experienced and novice teachers have provided glimpses into classroom practice and insight into the social and cognitive aspects of the learning environment. For example, in an interactional analysis of teacher and student roles in the classroom, Wood (1995) used discourse to document the transition in a teacher's practice from traditional to

inquiry-based teaching. Elsewhere, Peressini and Knuth (1998) analyzed the function of discourse in an experienced secondary mathematics teacher's classroom to establish the effect of a professional development program on that teacher's ability to cultivate meaningful discourse with his students. In similar work with pre-service teachers, Blanton, Berenson, and Norwood (2001) examined pattern and function in classroom discourse to explore the effect of students' discourse on a student teacher's practice during her professional semester. Elsewhere, we have used Valsiner's (1987) zone theory to examine patterns of discourse established by pre-service mathematics teachers (Blanton & Westbrook, 1998). Our inquiry showed that these teachers funneled students' thinking through leading questions that restricted the ZFM and established a ZPA organized around the teacher's conceptions. Such patterns of discourse appeared to promote verbalizations in the classroom that provided the illusion of sense making, yet instead established cognitive boundaries in the classroom. In the study reported here, we again use an analysis of discourse in participating teachers' classrooms to extend our previous inquiry into the practical and developmental applications of Valsiner's zone theory.

Method of Inquiry

Participants

We considered the teaching practices of three participants, Colleen, Mary Ann and Jimi (pseudonyms), to explore the ZFM/ZPA complex they established in their classrooms. Although chronologically the participants were at very different places in their teaching practices (Mary Ann and Jimi were student teachers and Colleen was in her tenth year of teaching), they were each novices in creating classrooms of student-centered inquiry. At the time of this study, Colleen was a 9th-grade science teacher participating in an 18-month project to develop and implement integrated mathematics and science curricula. As part of this project, she had had several opportunities to participate in and teach investigative lessons. She was considered an exemplary teacher by her peers and had been selected by her principal to teach the experimental integrated curriculum. Colleen was content oriented

and highly motivated by a desire to see her students score well on mandatory, statewide examinations.

Mary Ann and Jimi were in their final academic year of teacher preparation in a program aligned with current reforms in mathematics education. They were both student teaching in urban schools; Mary Ann was assigned to a 7th-grade classroom in which she taught general mathematics and pre-algebra and Jimi was assigned to a 6th-grade classroom in which he taught general mathematics. Both had supportive cooperating teachers, although their cooperating teachers were quite different in what they valued as successful teaching. Both were members of a cohort of 47 students participating in an ongoing investigation of the sociocultural mediators of learning during the professional semester and were selected for this study because of their overall academic standing.

Data Collection and Analysis

Mary Ann and Jimi were observed by one of the authors approximately once per week during their one-semester teaching practicum. Each visit, documented by the observer's field notes and audio and video recordings, included two classroom observations and a 45-minute interview with the student teacher. Data were collected from Colleen's class during daily, two-hour classroom observations of a three-week investigation on electricity. Audio and video recordings were used to document daily small group and whole class discussions. Interactions among a selected group of students during laboratory sessions were also taped.

Verbatim transcripts of classroom observations of each of the participants were prepared and subsequently analyzed by categorizing the verbal data. The tapes, transcripts and the researchers' notes served as the primary data sources for this study. The research team independently and collectively analyzed the transcripts, viewed the videotapes, and developed assertions from the classroom discourse about the zones established by the classroom teachers. Once assertions had been developed and the classroom zones had been

characterized, the data were further analyzed for confirming or disconfirming evidence of our findings.

Findings and Interpretations

The Phantom Zone of Promoted Action

In order to describe the ZFM and ZPA organized by each of the teacher participants and how these zones informed our understanding of the teacher's ZPD, it is necessary for us to first define an additional zone that we found to coexist with the ZFM and ZPA. We describe this additional zone as the 'phantom' zone of promoted action (PZ) and define it to be a zone of permissability that the teacher appears to establish through behaviors and routines used in instruction but in actuality, he or she does not allow what it seems is permitted. We characterize this as a phantom zone because it reflects an apparent contradiction in how the ZPA and ZFM interrelate. That is, in theory the ZPA should be contained within the ZFM; one can only promote what is at least allowed. However, the PZ represents precisely that which appears to be promoted (hence allowed) but in fact is not allowed. In this sense, we maintain that part of the ZPA can be illusionary and thus exist outside the ZFM/ZPA complex. By either its existence or absence in a teacher's practice, the PZ ultimately became significant in our understanding of each teacher's ZPD.

In what follows, we have organized our findings by first presenting our characterization of the ZFM and ZPA established by the participants at particular points in their practices. We note that our goal is not to use the ZFM and ZPA to characterize their teaching throughout the period of data collection, but rather to use their practices as a context for establishing and describing the ZFM/ZPA complex as a potential explanatory model for teacher development. We follow this with our assertions about the PZ and its relation to these teachers' development within their ZPDs.

The ZFM/ZPA Complexes Established by Mary Ann, Colleen, and Jimi

Mary Ann's case. We analyzed discourse in Mary Ann's classroom in order to define the zones she organized for her students. Elsewhere, a discourse analysis of Mary Ann's

teaching during her practicum (Blanton, Berenson, & Norwood, 2001) showed a progression in the type of interactions she promoted with her students from a 'teacher as teller' paradigm in which Mary Ann's practice was to give information and elicit student responses through primarily short-answer, leading questions, to a more reform-minded practice of teaching in which Mary Ann promoted activities of purposeful conjecture, argumentation and justification. Our purpose here is not to explore or document this shift or why it might have occurred (see Blanton, Berenson, & Norwood, 2001 and Blanton, Berenson, & Norwood, (in press) for a detailed treatment of this), but to identify the zones she established in these two essential phases of her teaching. Moreover, we give this dual picture of Mary Ann's practice because, as we will explore later, we found her transition to be significant in how we understood the role of the PZ in Mary Ann's development. We coordinated our analysis with this prior work in order to select classroom data that were representative of the progression in her practice and from which we could interpret the zones she created. We include here two classroom scenarios in order to establish what we saw as being allowed or promoted by Mary Ann in her practice during her professional semester. The first protocol is representative of the type of discourse that occurred during the early part of her teaching (that is, during the first four weeks of a fourteen-week semester). In it, Mary Ann led a whole-class discussion with her students about the following problem:

Alex had $5 left in his wallet after he spent $12 on snacks and souvenirs at the Jubilee. How much money did he take to the Jubilee?

1	Teacher:	How much money did he spend?
2	Jim:	Twelve dollars.
3	Teacher:	Twelve dollars. OK, if he spent $12, would he be minus or plus?
4	Students:	Minus.
5	Teacher:	Minus. He's going to be minus. So how much money he took to the Jubilee is an unknown. It's something that we don't know…. So,

		how do we represent unknowns?
6	Students:	Variable.
7	Teacher:	A variable. OK, what variable do [you] want to use?
8	Mark:	M.
9	Teacher:	OK, so m is the amount of money he has, and how much did he spend?
10	Carol:	Twelve.
11	Teacher:	Twelve dollars. And how much did he have left over?
12	Students:	Five.
13	Teacher:	(Mary Ann writes the equation 'm – 12 = 5' on the OP to be solved.) OK, what was the very first step [in solving this equation]? What was the very first step that I gave you yesterday Chad?
14	Chad:	Isolate the variable.
15	Teacher:	Isolate the variable. OK, how did we isolate the variable?

We infer from the above protocol that, while Mary Ann promoted the illusion of sense making, her forms of questioning necessarily restricted students' ZFM. That is, by asking short-answer, leading questions (e.g., 1[2], 3, 7, 13) Mary Ann seemed to be restricting students from essential problem-solving activities such as purposeful conjecture and argumentation. In this sense, we would argue that Mary Ann established a PZ in that students were invited to participate in class discussions, but only in a manner that funneled their responses toward Mary Ann's approach for solving the problem. We characterize this aspect of her early practice as structurally equivalent to what Mehan (1979) described as an 'initiation-reply-evaluation' pattern of interaction between teacher and student. We suggest that through this pattern, Mary Ann promoted students' (verbal) participation, yet her questions placed cognitive boundaries on their thinking. For example, in (3), rather than asking students what mathematical operation they might use to describe the process of

[2] Numbers refer to lines in the protocol.

spending money, Mary Ann gave students two possible responses ('minus' or 'plus') from which to choose. Students were also asked to name a letter to represent a variable (7), identify relevant information in the problem (1, 11), and recall previously learned information (5). While this did allow students to participate in the discussion, the extent to which they participated was filtered through Mary Ann's form of questioning. Ultimately, it was Mary Ann (not her students) who completed the more challenging part of the problem, namely, synthesizing information to generate the model '$\underline{m} - 12 = 5$' for the word problem. Through her questioning routine, we suggest that Mary Ann did not allow students to engage in forms of argumentation by which students could themselves develop a model for the problem. Thus, while it was clear to us that Mary Ann valued students' participation in her class, we maintain that she promoted a type of interaction with students in her early practice that necessarily canalized the development of their mathematical thinking in a direction which treated mathematics as a procedural body of knowledge. We have depicted the zones Mary Ann established in her early classroom practice in Figure 3.

[INSERT FIGURE 3 ABOUT HERE.]

Figure 3. The ZFM, ZPA, and PZ established by Mary Ann in her early classroom practice.

Having explicitly described the zones Mary Ann established in her early practice, we include a second protocol here that was representative of Mary Ann's practice of teaching during the later part of her professional semester. It depicts a student-based investigation of the number of diagonals in a polygon, with students using geoboards to model the particular cases. In this episode, after students shared their results for the number of diagonals in a triangle, quadrilateral, pentagon, and hexagon, Mary Ann asked them to find a pattern in order to predict the number of diagonals in a heptagon. The following excerpt chronicles part of this whole-class discussion:

16	John:	I think 12 (diagonals in a heptagon).
17	Teacher:	You think 12?... Do you have something to back up your prediction? [Some way]...to test your hypothesis?
18	John:	I did, but it's wrong.
19	Teacher:	Well, maybe not. Maybe if we test it. Lisa?
20	Lisa:	I have 12.
21	Teacher:	O. K., so Lisa and John think it's 12. O. K., so John and Lisa,...tell me how you got 12.
22	John:	Well, each one of those says increased by, uhm, a number higher than each other, but...
23	Teacher:	O. K., I didn't understand that. So, you must have said that not in my lingo. So, break it down.

As John continued, Mary Ann stopped him again for clarification

24	Teacher:	Whoa! O. K., so you go....
25	John:	You increase [the number of diagonals in a triangle] by 2 [to get the number of diagonals in a quadrilateral], then you add another one and increase again by 2 [to get the number of diagonals in a pentagon]. [The number of diagonals in a quadrilateral will] increase by 3.
26	Teacher:	O. K., so tell me. [The number of diagonals in a triangle] will increase by 2. So we increase by 2 here (referring to the number of diagonals in a triangle). Now tell me where I go from there.
27	John:	Then you add 1[to the number of diagonals in a quadrilateral] and increase by 2 again. Then [the number of diagonals in a quadrilateral] increases by 3.

(John's pattern involved finding the difference in the number of diagonals in successive polygons. From this, he determined the value to add to the number of diagonals in a hexagon in order to predict the number of diagonals in a heptagon.)

We found this excerpt to suggest that Mary Ann established a different type of ZFM/ZPA complex than she had in her earlier practice. For example, she not only promoted students' acts of justification (17), but allowed them opportunity for this (22, 25, 27). The significance here is that she did not seem to invite a student to engage in a sense-making process and then exclude the student from this by her form of questioning. That is to say, a PZ did not materialize in this interaction. Instead, she promoted students' participation in the dialogue in a way that centered on students' thinking, not the teacher's (e.g., 26). Indeed, what was striking to us as we compared the two protocols from Mary Ann's classroom was her own engagement in John's strategy for finding the pattern (23, 24, and 26). Unlike her early practice (1-15), here she did not privilege her own ideas about the problem solution, but promoted students' activity of testing conjectures (17, 19) and justifying solutions (21). Figure 4 illustrates this second phase of Mary Ann's practice. While we will later explore the implications of this shift, we note here that Mary Ann seemed to have transitioned beyond the stage of a PZ in this aspect of her teaching. That is to say, she seemed to be at a developmental point in which her actions matched her rhetoric. As we will describe in the next case, this transition did not occur with Colleen.

[Insert Figure 4 here.]

Figure 4. The ZFM and ZPA established by Mary Ann later in her practice.

Colleen's case. Our analysis of discourse in Colleen's classroom revealed that students believed they were in charge of their own learning. As one student commented, "in this class we figure things out for ourselves, and like [sic] we tell [the teacher]". However, we found that the classroom environment was not under their control in the way they

imagined. Instead, Colleen, like Mary Ann, seemed to establish a PZ in which students were encouraged to actively participate in classroom conversations. However, when students unwittingly "walked into the zone", Colleen reacted as though the interactions were inappropriate or ignored students' input altogether. She did not seem to allow input from students when their ideas did not directly relate to the content, when she herself did not understand their ideas, or when students gave a response different than what she wanted. For example, in a discussion about circuits that occurred at the beginning of the three-week investigation, Colleen overlooked Matt's response to one of her whole-class questions:

28 Colleen: Because what do we want in a circuit? What do we want?

29 Matt: Light.

30 Colleen: What kind of pathway? We want a complete pathway. A circuit is a complete pathway. Right? We need that.

The PZ also materialized when student comments that were not deemed on target by the teacher were repeated with a questioning tone or were deflected and left unanswered. In one such instance during a discussion about current in a series circuit, one of the students used the word "decelerating" to describe the shape of a graph representing the current versus the number of resistors in a series circuit.

31 Colleen: What does the graph tell me without looking at the data? If I just looked at the graph, what does the graph tell me? As the number of bulbs increases, what happens to my current?

32 Student: Decelerating.

33 Colleen: Are we decelerating or accelerating? (Laughs.)

34 Student: [Changes the words.] Decreasing.

The student's "wrong" answer here could have afforded the class an opportunity to connect the content of this discussion to topics that had been addressed earlier in the school year. Yet, as this protocol illustrates, Colleen did not seem to promote students sharing ideas that

were contrary to the accepted knowledge in the classroom during whole class discussions. The following protocol illustrates another instance in which Matt attempted to relate his own work experiences with an electrician to the ideas about resistance and current that were being discussed in the class.

35✱ Colleen: What's a resistor or resistance? What would be an example up there? [Refers to a drawing on the board.]

36 Matt: Wire. Well, sort of, wire slows . . .

37 Colleen: [Cuts in.] I thought that was a conductor. It has metal in it.

38✱ Matt: It depends on the amount of cord you have. If you plug in right there and go all around the school and come back it will have less juice in it when it comes back. I've done that a lot of times. You don't get as much.

39 Colleen: Okay. What are some others? Up here on our drawing, what would be three really good examples of resistors?

40 Erin: Light bulb.

41 Colleen: Right. Like a light bulb.

As Colleen passed over Matt's contribution, he muttered "Yeah" and turned his head away from the board and the conversation and started talking to members of his group. We suggest that this protocol further illustrates the zones that Colleen established for her students in which students' ideas that were not directly related to the content or that the teacher did not understand were not allowed to become part of the discussion. For example, Colleen's response (37, 39) seemed to be to ignore or verbally shut down Matt's suggestion. No follow-up questions were asked and no attempt was made to allow Matt's experience to become part of the classroom sense making process. In fact, Colleen had asked students to get their information from what had been written on the board (35). We concluded that a cognitive boundary was established by Colleen's verbalizations that limited the extent to which students such as Matt could negotiate meaning in the context of the teacher-facilitated, whole class interaction.

We found that Colleen promoted student involvement in discussions by asking many questions during each class and recording students' responses on the board. However, as the classroom protocols suggest, the ZFM she established did not include conjecturing or bringing in outside information. In this sense, she seemed to control not only the flux of ideas, but their origination (i.e., within the classroom context) as well. In fact, Colleen limited students' input to answers that would fit the allotted space in students' lab or data sheets.

Colleen also did not allow cognitive confusion in the classroom. Earlier in the implementation of the project, she clarified her beliefs about this: "When they are confused, I'm confused, and I don't like to be confused." Instead, Colleen worked to prevent confusion or irritation from entering the classroom and used these affective responses from students as a determinant for her continuation on the integrated curriculum project. She noted, "I haven't gotten any comments from students.... If I was hearing the negative from them day in and day out, that would probably be the number one thing that would probably make me say [about the integrated curriculum project], 'Forget it!'."

Finally, as we noted earlier, the PZ was illustrated in Colleen's class (as in Mary Ann's) by the illusion that sense making was a part of the classroom environment. Sense making was indeed intended to be part of the classroom discussions in that students were to make sense of their data in order to invent target concepts and to extend their understanding of those concepts. However, the asking and answering of questions in Colleen's class did not constitute an opportunity for the communal development of ideas. Colleen invited students into the PZ by asking what appeared to be open-ended questions during the whole class discussions. However, as she facilitated those discussions, she filtered students' answers in order to get her desired response. Moreover, the ultimate focus of class discussions appeared to be getting through the information and moving to the next activity. In fact, Colleen was often concerned about the time discussions took and would make references to the need to "hurry", or "move on to something else". In this sense, we argue

that the sense making she advertised was in reality not allowed and, hence, constituted part of the PZ. Figure 5 depicts our interpretation of the zones Colleen established in her classroom.

[INSERT FIGURE 5 ABOUT HERE]

Figure 5. A depiction of the ZFM, ZPA, and PZ established by Colleen in her classroom.

Jimi's Case. Jimi's practice contrasted deeply with that of Colleen and Mary Ann. In fact, one of the significant results from our analysis was that a PZ never materialized in his teaching. That is, he did not promote any events or actions that ultimately he did not allow. While this could mean several things, we found in Jimi's case that not only did he not advertise events indicative of reform-based practice, such as student sense-making through appropriate forms of discourse, he also did not promote the illusion that students could engage in such events. We found instead that he structured a highly restrictive ZFM marked by the absence of discourse. Moreover, since he rarely allowed what he did not promote, the ZPA he organized was essentially equivalent to the ZFM. In order to characterize the zones he established, we first describe a typical day in Jimi's 6th-grade general mathematics class.

> As students entered the room, they began to work on a task to determine if a set of numbers listed on the board was divisible by 2, 3, 4, 5, and so on. Students were expected to use previously stated rules to determine their answers and were occasionally asked to state, in writing, the rule used. All of this occurred under a strict mandate of silence. After a rapid review of students' answers, Jimi checked students' homework solutions, informing them that he would only give solutions to those problems relevant to the next test. As he quickly called out the

correct answers, no student attempted to verbally make sense of their work or question the solutions, and the task was quickly completed.

Jimi then shifted to the goal of his lesson – performing long division. Although he commented that he was sure everyone had seen this before, he proceeded slowly, step-by-step, through the procedure of long division. At no time did he at least ascertain students' ability to do long division, but focused methodically on the process at hand, emphasizing to students the importance of actions such as arranging numbers neatly. At the conclusion of the division problem, Jimi noted that the last step was to use the notation 'r2' to indicate a remainder of 2. When one of the students accurately pointed out that '2/3' would be another way to express the remainder (3 was the divisor), Jimi stated that while it might be a mathematical alternative, it was not an alternative in his class.

He then required students to copy the procedure for long division, written in advance on an overhead transparency, into their notebooks. When a student interjected a mnemonic for remembering the procedure – Dad (divide), Mom (multiply), Sister (subtract), Brother (bring down) – Jimi responded, "You can use it if you want, but you still have to copy these rules in your notes". A second student jumped in and offered "Dirty Marvin Smells Bad" as another mnemonic. Jimi responded, "This is your last warning", indicating to us that he viewed this students' input as a behavioral problem. As the students copied the notes from the overhead, he placed a practice problem on the board. A student asked if she could proceed with the practice problem, but Jimi responded that she could not until he said so. Within two minutes, he indicated that students were now allowed to start the practice problem. After students completed the problem, Jimi "allowed" them to work the problem on the board as a form of reward. In particular, selected students took turns, one-by-one, completing the long division task at the board. Their turn was over when Jimi said, "stop". After completing several more

practice problems in this manner, Jimi instructed students to work quietly on their homework.

Jimi conveyed his words in a monotone that helped to assert his position of authority. The atmosphere in the classroom seemed repressive and heavily scripted, with all moves originating with the teacher. In fact, 'discourse' essentially consisted of Jimi's words followed by strictly enforced silence. Student talk seemed to be an interruption, and throughout his lesson there seemed to be no attempt to make sense of the tasks or build understanding about division. In fact, Jimi revealed his disregard for students' thinking when he noted in an interview that students had no idea of what they needed to do. In essence, no actions other than those promoted by Jimi were permissable and nothing unexpected was welcomed in the "community" which he had established. Because of this, we maintain that the ZFM he constructed for students was narrow and coincided with the ZPA. That is, for the most part students were not allowed to make moves outside those promoted by Jimi, and he had a very narrowly defined set of allowable moves. We have depicted the type of ZFM and ZPA Jimi established in his classroom in Figure 6. We have also included in this those actions that were outside the ZFM he established and that, unlike those of Mary Ann and Colleen, did not exist in a PZ.

[INSERT FIGURE 6 HERE]

Figure 6. A depiction of the ZFM and ZPA established by Jimi in his classroom.

Assertions about the PZ and Its Relation to the ZFM/ZPA Complex

Given what we have identified about the zones established by Mary Ann, Colleen, and Jimi in their respective classrooms, our task was to glean understanding from these cases about the role of the PZ, the ZFM, and the ZPA in their development. In particular, how did the ZFM/ZPA complex, and the PZ as an extension of it, inform us about their ZPD? In this section, we use their cases to establish our assertions about the relationship between these zones.

Assertion 1: The PZ is a precursor to the reconfiguration of the ZFM established by the teacher and as such, constitutes a developmental necessity for that teacher. By this, we mean that the PZ represents, developmentally, a place of potential transition for the teacher. As we have described earlier, both Colleen and Mary Ann (in her early practice) established a PZ in their classrooms by promoting the illusion of sense making through students' verbal participation. However, from our analysis, we found that the PZ did not appear in Mary Ann's later practice of teaching. That is, she ultimately expanded her ZFM by promoting and allowing students' activities of sense making. Thus, what had been a PZ for Mary Ann transitioned into a set of activities that existed within the ZFM/ZPA complex and was not illusionary. On the other hand, we observed no such shifts in Colleen's practice; the zones she established in the classroom continued to include a PZ. From Jimi's case, the lack of an observable PZ seems to support this assertion as well. In other words, teacher development did not occur in a particular area without the presence of a PZ initially. As a caveat, we clarify that the PZ indicates only a potential for development. For example, Colleen may or may not have transitioned beyond her PZ after our period of observation. Thus, from the empirical classroom data, we posit that the PZ signals a transitory and necessary state in a teacher's development. That is, it indicates a potential for development, although its existence does not guarantee that the teacher's practice will develop beyond it.

We find further support for our claim from a Vygotskian theoretical perspective. In particular, we suggest that the construct of the PZ parallels Vygotsky's (1962/1934) notion of pseudo-concept, which he used in describing the development of higher mental functioning in children. Vygotsky argued that the pseudo-concept is an essential bridge in children's thinking to the final stage of concept formation. While the pseudo-concept a child possesses is phenotypically equivalent to that of an adult, it is psychologically different. As a result, the child is able to "operate with [the concept], to practice conceptual thinking, before he is clearly aware of the nature of these operations" (p. 69). Applying this to our study, we found that the PZ signaled that desirable teaching practices might be

within the teacher's ZPD although the teacher might not yet have a fully articulated understanding of those practices. For both Mary Ann and Colleen, we observed their intent to engage in the kinds of practices that promoted students' sense making, although this intent was not realized for Colleen beyond a pseudo-conceptual stage. Jimi never exhibited this intent. As such, we see the PZ as a zone of possibility, or a ZPD where with mediation there is potential for growth. Thus, identifying its existence in a teacher's practice helps us to understand that potential for growth. As such, we maintain that when a teacher is operating within a PZ, she is in a place of transition, or a pseudo-conceptual stage, and has the potential for professional development to be effective.

Assertion 2: The PZ is transitional when the teacher is able to construct a communal ZPD. From our previous claim that the PZ represents a place of potential growth, our question became what aspect of Mary Ann's practice facilitated that transition, while Colleen's practice did not exhibit such change? We found that while Mary Ann did establish a PZ, its constitution was different than that of Colleen's. Our claim is that this may indicate why Mary Ann, unlike Colleen, was able to move beyond the PZ. If we take a PZ as being defined by what is promoted but ultimately not allowed, then Mary Ann (in her early practice) and Colleen could both be described as promoting some form of dialogue and having a shared belief in its importance, yet creating a learning environment that restricted students' cognitive movements. We conjecture that Mary Ann was able to reorganize her ZFM in part because she allowed herself to make sense of students' ideas and as she did so, she was able to become engaged by students as a learner (see 16-27). In other words, we suggest that she was able to construct a communal ZPD (Wells, 1999) for her students whereby she allowed herself to co-participate in sense making with them. Wells' notion of a communal ZPD entails a community of inquiry whereby "jointly undertaken activity creates a context in which all participants – teachers … as well as students – can assist each other in their zones of proximal development" (p. 312). He further argues that "for learning to occur in the ZPD, it is not so much a more capable other

that is required as a willingness on the part of all participants to learn from and with each other" (p. 324).

While we recognize that many factors contribute to a teacher's development, we suggest that Mary Ann's capacity to participate with her students in a communal ZPD contributed to a transition in her practice. Prior to this transition, Mary Ann was at a place developmentally in which she seemed to value dialogic discourse (as did Colleen), but did not yet have an image of what that might be nor the cognitive tools with which to cultivate it. We take as evidence for this the fact that, prior to any mediation of her practice, Mary Ann's teaching was characterized by the protocol given in (1-15) (see Blanton, Berenson, & Norwood, 2001). In essence, we see her early practice of how she interpreted and enacted a discourse of inquiry as being at a pseudo-conceptual stage of operation. While Mary Ann exhibited a transition in her practice, Colleen continued to stay focused on making sense of her own ideas, thereby excluding students' participation in real sense making. That is, Colleen was never able to fully move away from an authoritative position and participate with students as a learner. Thus, we emphasize that the existence of a PZ in her practice illustrates its capacity to indicate the potential for development, but it is not a guarantee of such. From this, we conclude that a teacher can develop beyond the PZ if she is able to construct a communal ZPD as Mary Ann did. Thus, we again suggest that the PZ may act as an external manifestation of the ZPD and thus a predictor of one's readiness for professional development.

Assertion 3: The more restrictive the ZFM is that the teacher organizes for students, the larger or more inclusive the mentor needs to construct the ZPA in the mentoring environment with that teacher in order to access his or her ZPD. We note that, given the relationship between the ZPA and ZFM, the effect of a larger ZPA is necessarily that of a larger ZFM as well, since one can only promote what is at least allowed. (Otherwise, a PZ is created when what is being promoted is not allowed.) So, when we consider here the ZPA that the mentor (e.g., teacher educator, university supervisor, cooperating teacher)

should construct for the classroom teacher, we are partially describing the ZFM, or what the mentor allows, as well.

When a teacher constructs a restrictive ZFM in the classroom, he is limiting students' access to cognitive or literal areas or objects, or ways of acting on these objects. This was seen most clearly in the case of Jimi, who established an environment that severely limited students' cognitive movements. In particular, students were not given the opportunity to be freely and openly engaged by ideas in order to build understanding. Thus, we ask what information does a teacher's establishment of a narrow ZFM (as in Jimi's case) tell us about how to mentor that teacher? We argue that in response the mentor must structure a broader, more inclusive ZPA in the mentoring relationship if he or she is to access the teacher's ZPD. In other words, the actions or events that are promoted by the mentor must be an inclusive set or it will not overlap with the teacher's ZPD and hence no mediation can occur. For example, with Jimi any mediation that promoted only high levels of student interaction with the content would have been out of his ZPD. Indeed, from our analysis, we question if he could have created an investigative, inquiry-based classroom as a starting point in his student teaching. Thus, it would have been necessary to promote instructional practices that were more attainable by him, resulting in the construction of a more inclusive ZPA by the mentor.

In conjunction with this, pairing Jimi with a highly reform-based cooperating teacher or one whose image of teaching was very similar to Jimi's would likely have minimized or precluded his development. In the former case, the mentor would likely have operated outside of Jimi's ZPD, while in the latter, there would have been no challenge to Jimi's practice. As it turned out, Jimi's cooperating teacher was very supportive of his practice and promoted his traditional teaching behavior. The result was that she did not mediate his practice towards reform-based techniques such as student investigation and inquiry.

Thus, knowing how a teacher constructs a ZFM (and hence ZPA) informs us about how the mentor should construct the ZPA in the mentoring relationship in order to optimize

teacher development. Moreover, understanding the types of behavior and practices that a mentor would promote informs us about what type of mentor would most likely be able to operate within the teacher's ZPD. In this sense, understanding the ZFM/ZPA complex that the teacher constructs in the classroom gives us predictive power over the teacher's ZPD and will enable us to more effectively mediate that teacher's development by the resources, both human and material, that we provide.

Conclusion

In this study, we explored Valsiner's zone theory as a way to better understand the ZPD of three mathematics and science teachers at novice points in their practice. Our analysis indicated that the ZFM and ZPA established by the teacher in the classroom provided insight into that teacher's capacity for growth. In particular, we found that the existence of what we describe as a PZ, an illusionary part of the ZPA, signaled a transitory state in the teacher's development. That is, the PZ seemed to indicate that the teacher was at a pseudo-conceptual stage, with respect to some aspect of development, that represented a necessary but not sufficient condition for growth. We found that a teacher operating in a PZ had the capacity to describe an intended pedagogical technique, although his or her practice showed some type of deficiency between what was described and what was ultimately enacted by the teacher. Moreover, we found that a teacher was able to transition beyond the PZ when she became part of a communal ZPD with her students. As such, we suggest that the existence of a PZ signals the potential for mediation and can therefore help us understand how to structure the ZFM and ZPA in a mentoring relationship with a teacher in order to access his or her ZPD.

Additionally, if a PZ is not indicated and it is the case that the teacher has not transitioned through it, then the issue becomes accessing the teacher's ZPD so as to move him or her towards this stage of development. From our analysis of Jimi's practice, we maintain that when a PZ has not materialized and the teacher has constructed a narrowly defined ZFM in the classroom, then the mentoring relationship with the teacher will require

a large ZPA. However, more work is needed to understand the growth trajectories through which teachers progress and how the zones they construct in their classrooms inform us about the zones we should construct in teacher learning environments.

Our findings lead to several implications for mathematics (and science) teacher education. First, we need to understand the type of ZFM/ZPA complex that teachers establish for their students. In particular, the PZ gives us predictive power concerning the teacher's ZPD. That is, determining the existence of a PZ, or that the lack of one reflects a primitive stage in the teacher's development, will enable the teacher's mentor to characterize the potential for mediation and the scaffolding through which development can be optimized. Moreover, since a communal (classroom) ZPD seems to be a possible context in which teachers can develop, we must understand what a communal ZPD looks like and enable teachers to construct these in their classrooms and learn how to participate in them. In other words, we need to help teachers become comfortable with being reflective learners during the activity of teaching. Finally, the act of identifying the ZFM and ZPA in the classroom was for us a significant tool for analyzing practice. As such, we suggest that our interpretation of Valsiner's zones of interaction in the context of teacher education can serve as a prototype for others engaged in similar issues of teacher education.

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Figure Captions

Figure 1. Interaction of the ZFM, ZPA, and ZPD in development.

Figure 2. An interaction of the ZFM, ZPA and ZPA in a classroom context.

Figure 3. The ZFM, ZPA, and PZ established by Mary Ann in her early practice.

Figure 4. The ZFM and ZPA established by Mary Ann later in her practice.

Figure 5. A depiction of the ZFM, ZPA, and PZ established by Colleen in her classroom.

Figure 6. A depiction of the ZFM and ZPA established by Jimi in his classroom.

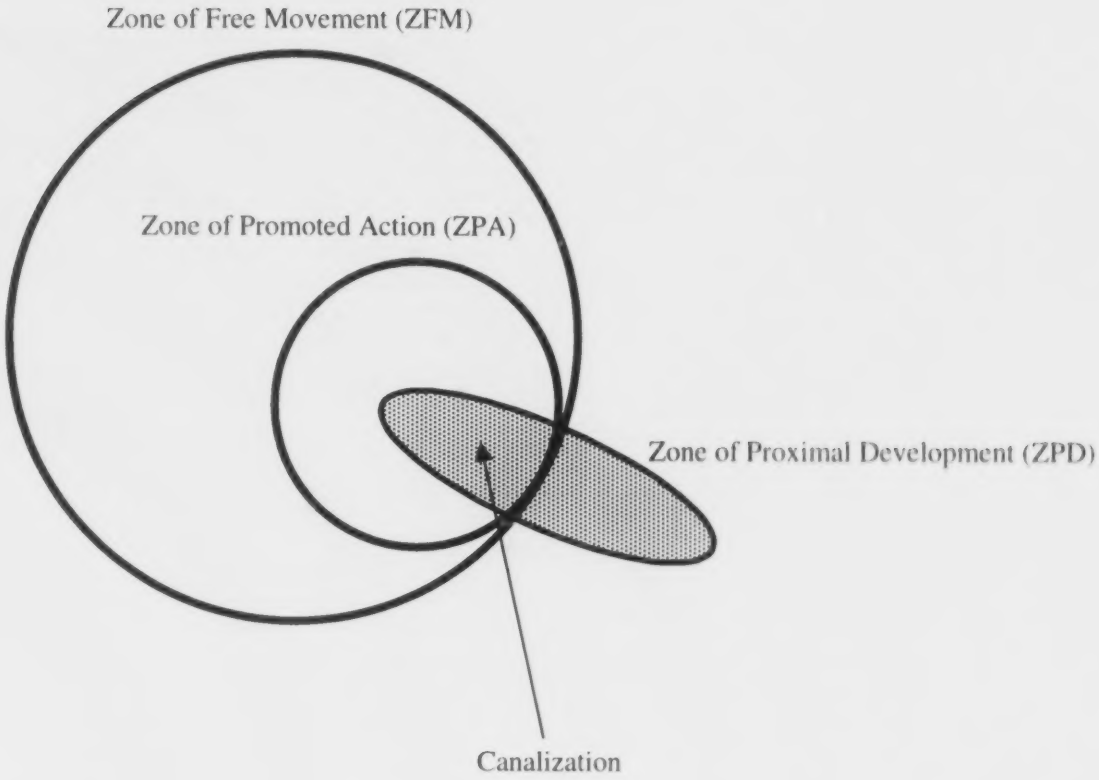
Zone of Free Movement (ZFM)
Zone of Promoted Action (ZPA)
Zone of Proximal Development (ZPD)
Canalization

Figure 1

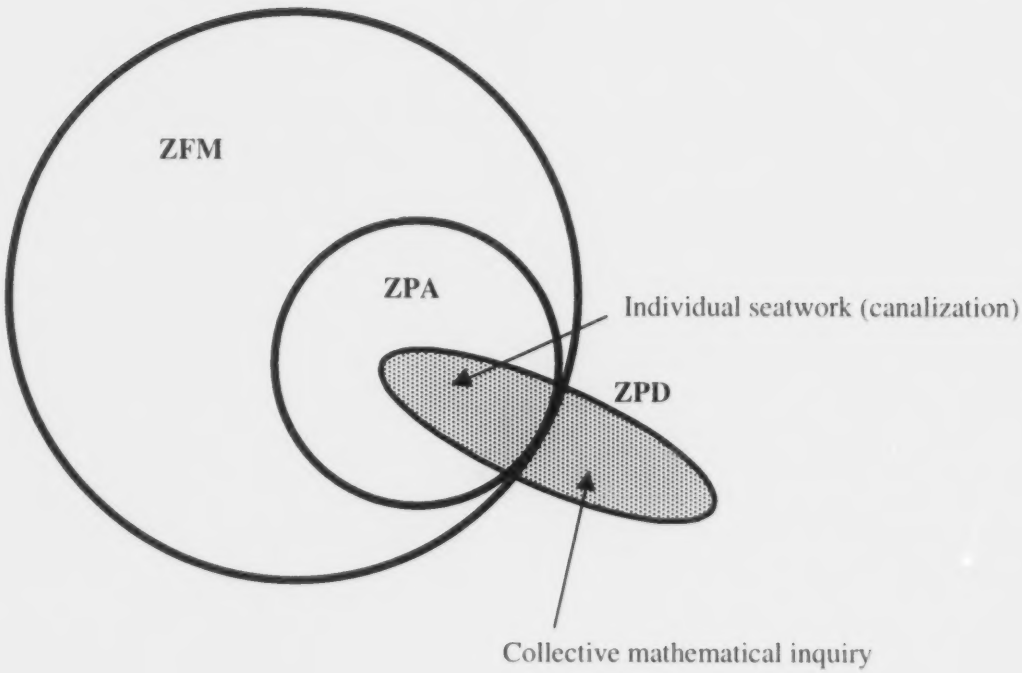
ZFM
ZPA
Individual seatwork (canalization)
ZPD
Collective mathematical inquiry

Figure 2

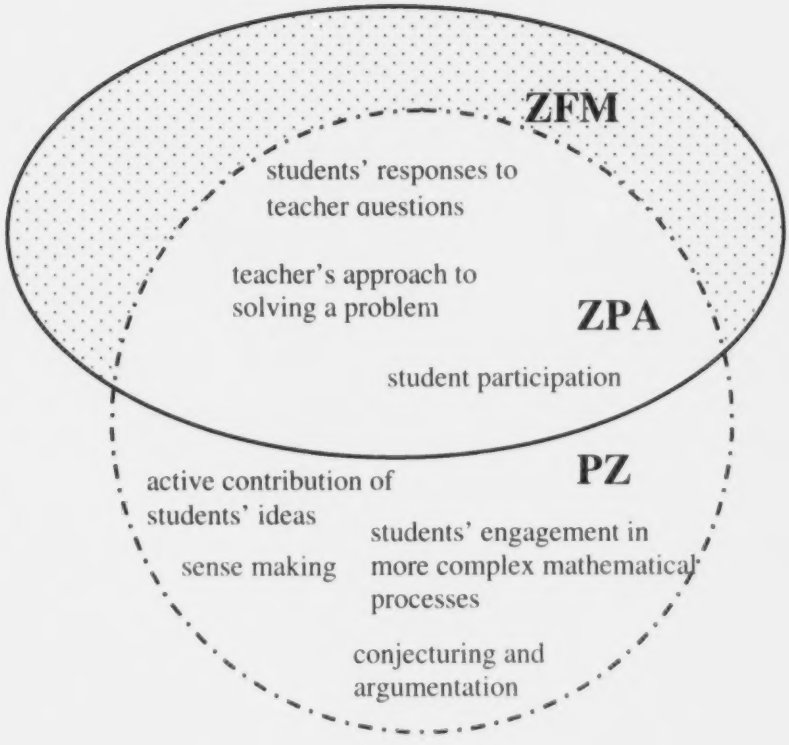
ZFM
students' responses to teacher questions
teacher's approach to solving a problem
ZPA
student participation
PZ
active contribution of students' ideas
sense making
students' engagement in more complex mathematical processes
conjecturing and argumentation

Figure 3

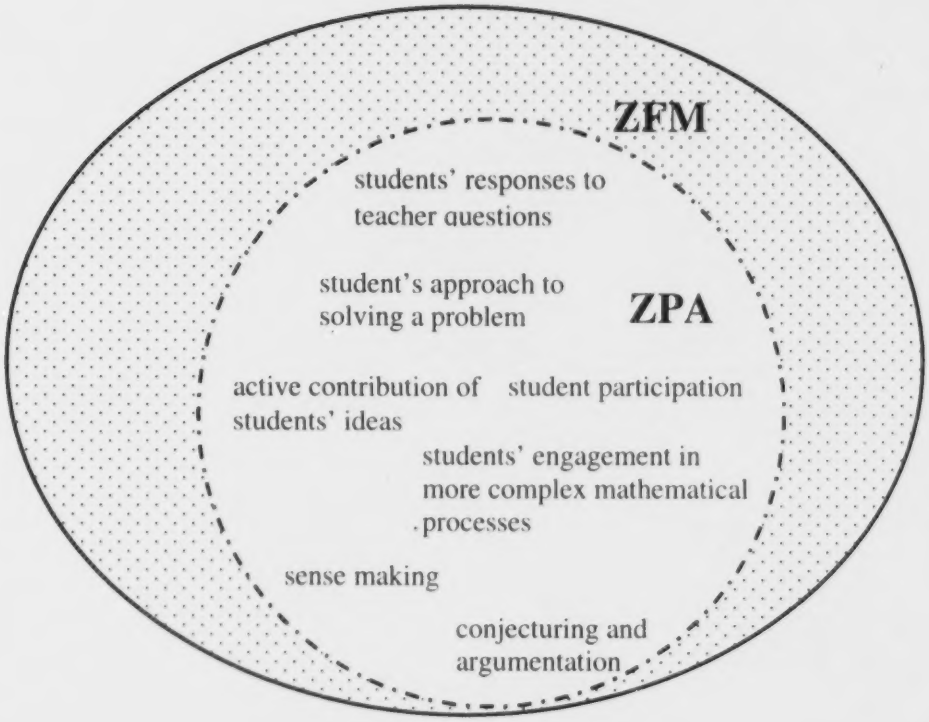
ZFM
students' responses to teacher questions
student's approach to solving a problem
ZPA
active contribution of students' ideas
student participation
students' engagement in more complex mathematical processes
sense making
conjecturing and argumentation

Figure 4

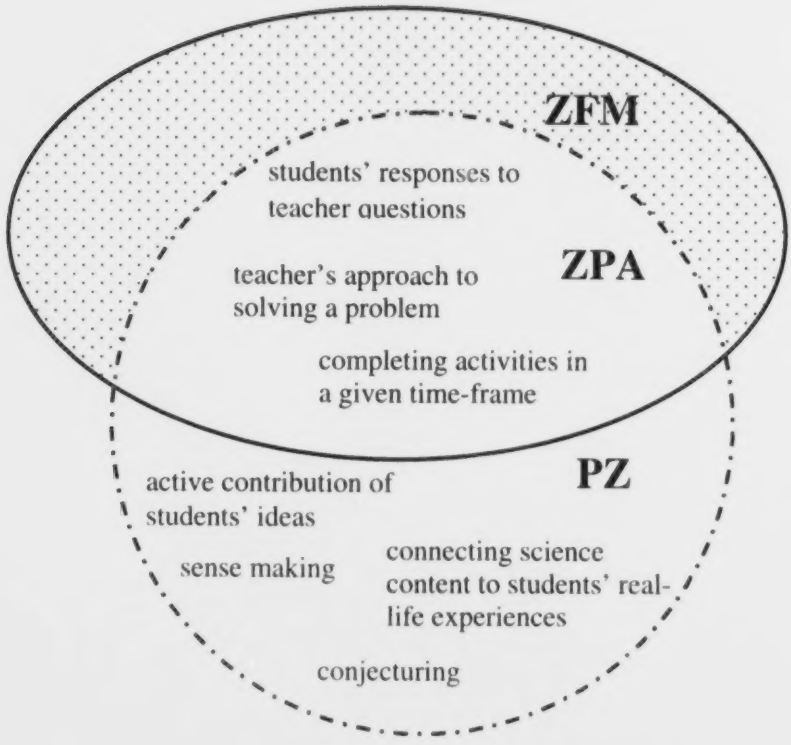
ZFM
students' responses to teacher questions
ZPA
teacher's approach to solving a problem
completing activities in a given time-frame
PZ
active contribution of students' ideas
sense making
connecting science content to students' real-life experiences
conjecturing

Figure 5

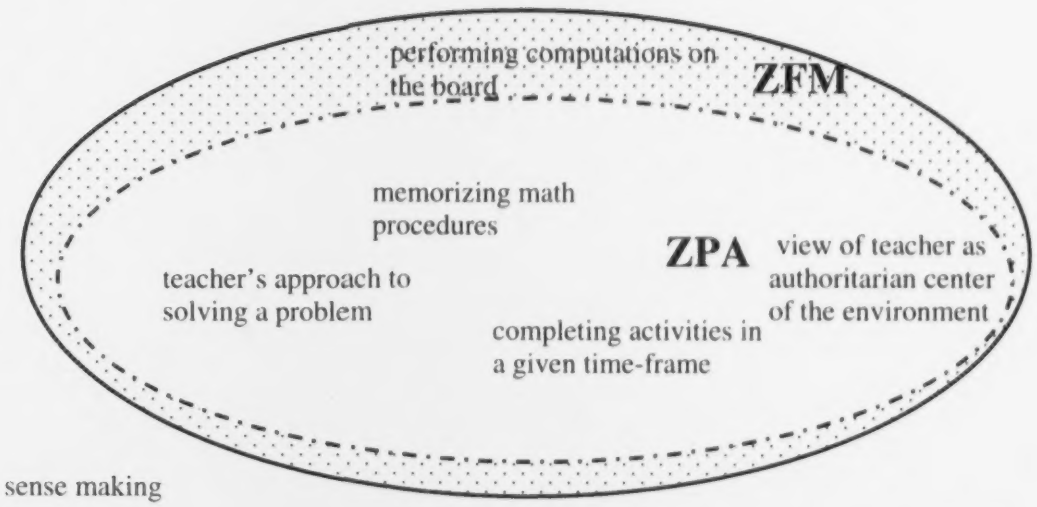

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Figure 6